The Commonwealth of Massachusetts

WATER RESOURCES COMMISSION

STRESSED BASINS IN MASSACHUSETTS

Approved December 13, 2001

Introduction

The 1999 work plan for the Massachusetts Water Resource Commission (WRC) directs an interagency committee to define a stressed river basin. The WRC has assumed this task in response to the large amounts of time and money regulators and project proponents must invest when trying to evaluate the potential environmental impacts of a project with limited background information on the natural resources of a site. In developing a definition of stressed basins the committee has produced an outline of the information which would identify an area as weak and an interim list of environmentally vulnerable (stressed) basins. The stressed basin classification is intended to flag areas which may require a more comprehensive and detailed review of environmental impacts or require additional mitigation. This information will speed up the process of project review for regulators.

This report summarizes the work of the committee and presents the general conclusions reached by the committee. It also includes more specific recommendations developed by DEM and EOEA staff for future work.

General Conclusions

- A definition of stress includes streamflow quantity, quality and habitat factors
- A lack of adequate quality, biological and hydrological data has necessitated the development of a method to define quantitative stress which was applied at the major basin and major sub-basin level.
- A second method has been developed to determine quantitative stress for a tertiary or secondary sub-basin which can be easily applied on a site specific basis, but has not been applied statewide as part of the classification developed under the first method.
- The second method should be used to refine basin stress classifications for tertiary or secondary sub-basins wherever possible

Limitations

- The committee recognizes that there are quality and habitat stresses and strongly recommends that the interim methods be used only as a first cut to determine hydrological stress.
- The delineation of stressed basins on a large scale is only a relative determination based on a comparison of measurements for Massachusetts' Rivers.
- The downstream gage data is not a good indicator of the condition of the entire basin. Headwater streams may be stressed even though the downstream data indicates no problems.
- The delineations are intended for highlighting areas needing further study and for defining mitigation for potential projects. Delineations are not intended to be used in any other way.
- The flow values used as criteria to define stressed basins are relative values and are not related in any way to habitat needs.
- The basin method using the stream gage data delineates rivers with low flows, relative to other basins, but does not indicate whether the cause is natural or man-made.

Definition of Stress

A stressed basin is defined as a basin or sub-basin in which the quantity of streamflow has been significantly reduced, or the quality of the streamflow is degraded, or the key habitat factors are impaired.

- **Quantity**: A significant reduction in streamflow is defined as a decrease in key low and high streamflow statistics. Low flows in most of Massachusetts reflect ground water levels and are a good indicator of the health of a system. Reduced low flows can impact aquatic habitat and water quality. In addition, low flows are often the first indicator of environmental impacts. However, where flood skimming operations or dam regulations occur, reductions in high flow statistics can be also be significant.

- **Quality**: A degraded water quality is defined as water in a stream that does not meet surface water quality standards.

- **Habitat Factors**: A degraded habitat is defined as a river reach in which key habitat factors, such as temperature, quality, cover, substrate and accessibility, necessary to sustain a biologically diverse community are degraded. The stress can be due to a lack of streamflow, quality degradation, presence of dams, channel modifications, culverting and other factors. Indicators of stressed habitat include the absence or degradation of a target fish or other aquatic community or the absence of the ability of fish to move between multiple habitats necessary to their life cycles. Factors that limit movement include lack of flow, or reaches with no flow, and the presence of dams or other restrictions that prevent passage.

In developing the stress definition, the committee reviewed many types of raw data as well as existing methods used to evaluate environmental impacts (a summary of the data and methods is included in Appendix 1). The committee put together the indicators of stress for which data is currently available or for which easy to use methods are available. The committee determined that there is sufficient information to use the quantity, quality and habitat criteria in a matrix to define sub-basin stress on a case by case basis. A sub-basin for which 1 or more of the criteria are met, would be determined to be stressed. Other factors which are important to quality, quantity and habitat have not been included in this definition because they are not currently available except through site specific field work. For example, habitat can be characterized by assessing cover, substrate riffles and temperature, however this data is only available through intensive field work.

Available Data and Methods

The following summarizes the information which is recommended for defining stress for the quantity, quality and habitat criteria:

- **Quantity**: A significant reduction in streamflow can be estimated by comparing the net amount of water lost from a sub-basin to a range of natural streamflow levels. The net water loss (or gain) can be determined by developing a hydrologic budget for the subbasin. The net water lost or gained can then be compared to estimated natural streamflows to determine the change in flow. This method is based on the inflow/outflow method used by DEM in the River Basin Plans. It is outlined in detail on Page 23.

- **Quality**: A degraded water quality can be determined by using the existing data on water quality included in the state's 303d list. This list of impaired waters is available on the DEP internet site in text form.

- **Habitat Factors**: Degraded habitat factors can be evaluated by reviewing presence/absence data for fisheries available in hard copy form from DFWELE. In addition a preliminary list of dams which impede fish passage is available in the 1998 303d list. Where sufficient data is available the presence/absence of a target fish community can also be used to determine habitat impairment (target fish community as defined by Bain and Meixler, 2000, see Attachment 3).

Early in the review process, the committee realized that a lot of the data is available only in hard copy form. A lack of computerized data make it impossible to delineate stressed sub-basins statewide in a timely manner. Therefore the committee completed a preliminary statewide assessment of quantitative stress on a basin scale using existing computerized flow data. In addition the committee developed a method which incorporates portions of the definition for interim use until a statewide assessment on a sub-basin level is possible.

Interim Methods for Applying the Stress Definition

This section outlines two methods to delineate **hydrologic** stress. Hydrologic stress focuses on the quantity criteria of the stress definition. Because streamflow is a basic requirement for quality and habitat factors selection of the hydrologic stress was deemed appropriate. The first method provides a first cut delineation of stress for large scale river basins and sub-basins across the state using stream gage data. The second method can be used by project proponents to determine whether smaller sub-basins are hydrologically stressed.

Interim Method to Delineate Hydrologically Stressed Basins

The interim method to delineate hydrologic stress for river basins involves the comparison of low flow statistics for 72 stream gages in Massachusetts (Figure 1 and Table 1). For the purposes of stressed basins, hydrologic stress is defined as the **relative** strength of rivers in Massachusetts. The numbers derived for this method are not useful outside of Massachusetts and are not based on habitat or quality needs. The hydrologically stressed basins represent the rivers with the lowest flows (per square mile of drainage area) in Massachusetts.

Most rivers and streams in Massachusetts have low flows in the summer, which are maintained by baseflow (groundwater discharge) to the stream between rainfall events. Streamflow during base flow events can be used as an indicator of the health of the sub-basin's ground water and surface water systems. In a few cases in Massachusetts, aquifers are confined and do not supply flow to streams, for example aquifers along portions of the Hoosic River. For the purposes of this report it will be assumed that base flow is maintained by groundwater and that a lack of sufficient base flow is due to a lack of aquifer material or to man made impacts.

The interim stressed basin method incorporates statistics used by the Nature Conservancy in the Indicators of Hydrologic Alteration (IHA). The IHA analysis produces 33 statistics for a stream gage. The IHA procedure involves determining whether the median of flow statistics for a river have been significantly changed over time. However the IHA analysis, which looks at changes in flow statistics due to a known stress, was not applied. In addition the program evaluates the daily streamflow values as compared to the values of the 25th and 75th percentiles for each statistic.

For the purposes of the stressed basin analysis, it is assumed that the median values of certain statistics, provided by the IHA program, are useful for comparing one river to another. Three low flow statistics are chosen: median of annual 7-day low flow, median of annual 30-day low flow and median of low pulse duration (see IHA web site for more detailed description of parameters at www.tnc.org). The median of the annual 7-day and 30-day flow statistics for each gage are calculated and converted to a unit of flow per square mile of drainage area (cfsm). The low pulse duration in days is also calculated. The median values for the gages are then sorted and ranked (Tables 2-4). Three lists of median flows are developed, one for each statistic. The quartiles of the medians for each statistic are then calculated. The quartiles of the median are used as the thresholds in classifying the relative strength (high, medium, low) of the basin for each flow statistic. For low flow statistics, a classification of high is given to values below the 25th percentile, low is given to values above the 75th percentile and medium is given to values between the 25th (Figures 2-4) and 75th percentiles (the thresholds for high and low are reversed for the low pulse duration). A matrix of the statistics is developed (Table 5). Gages with high values for 2 (or 3) out of 3 statistics are considered stressed.

A number of statistics were evaluated for use in the classification in addition to the 7-day low flow, 30-day low flow and low pulse duration. However, many of the statistics resulted in the same ranking of gages within the high, medium and low classifications. The data was checked for trends, which would indicate the median for any gage is not indicative of current conditions. Trends were assessed using regression equations (which have limited use due to the high variability of flow) and graphical interpretation. Adjustments to the classifications are made where recent trends indicate the gage should be in a different group.

A list of high, medium and low gages is shown in Table 6. A map of these basins are presented in Figure 5. The gage information and data used in the analyses are also included in Table 1. Gages used in the analysis have at least 25 years of data, and 67% of the gages have over 50 years of data. Some gages have been discontinued. However, 67 gages have data through at least 1990. Most gages included part or all of the 1960's drought. Although inclusion of the drought period does not impact results because median values for the period of record are being used.

Figure 1 – map of gages used in stressed basin analysis

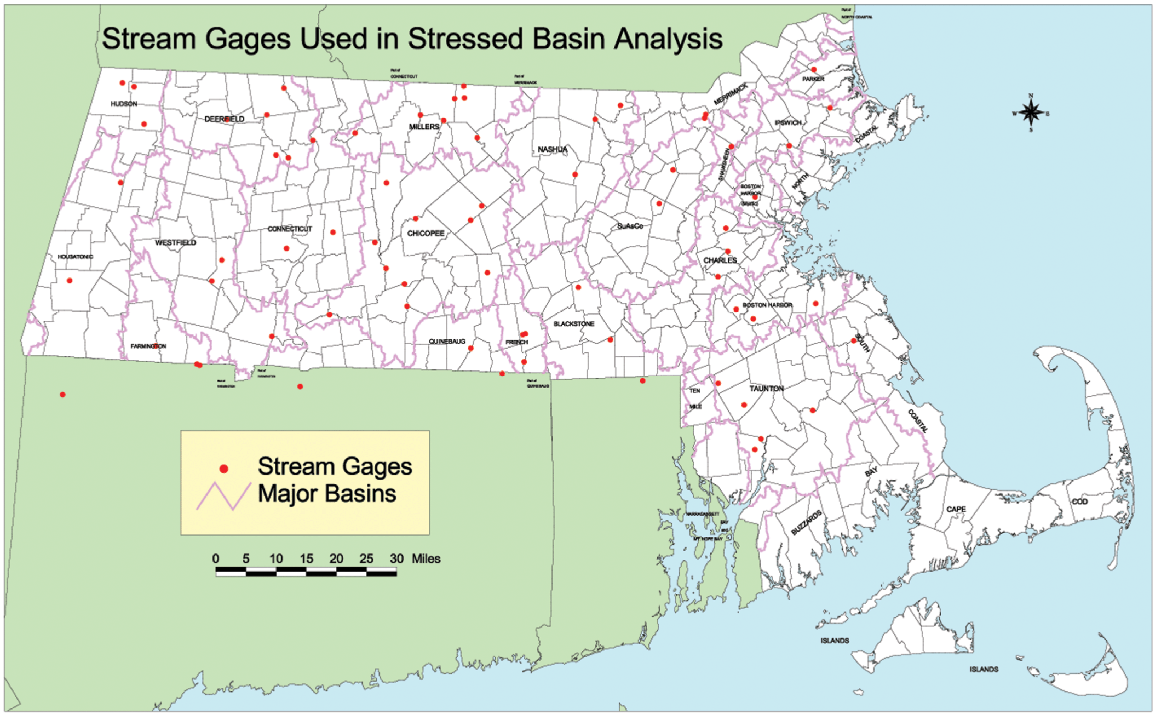


Table 1. - List of gages used in stressed basin analysis

Station #	Station Name	Drainage Area	Start Year	Stop Year	Period of Record** (yrs)
01102500	Aberjona River at Winchester*	24.7	1939	1997	59
01097000	Assabet River at Maynard	116.0	1941	1997	57
01112500	Blackstone River at Woonsocket	416.0	1929	1997	69
01174900	Cadwell Creek nr. Belchertown	2.55	1962	1997	36
01103500	Charles River at Dover	183.0	1938	1997	60
01104500	Charles River at Waltham*	250.6	1931	1997	67
01104200	Charles River at Wellesley	211	1960	1999	40
01177000	Chicopee River at Indian Orchard	689	1929	1999	71
01099500	Concord River below R. Meadow at Lowell*	400.0	1904	1997	94
01170500	Connecticut River at Montague	7860.0	1929	1997	69
01184000	Connecticut River at Thompsanville CT	9660.0	1929	1999	71
01168500	Deerfield River at Charlemont	361	1914	1999	86
01170000	Deerfield River nr. West Deerfield	557	1941	1999	59
01197000	E. Br. Housatonic River at Coltsville	57.6	1936	1997	62
01105500	East Br. Neponset River at Canton	27.2	1953	1999	47
01174500	East Br. Swift River nr. Hardwick	43.7	1937	1997	61
01165000	East Branch Tully River nr. Athol	50.5	1917	1990	74
01171300	Fort River nr. Amherst	36.3	1967	1996	30
01124350	French River at Hodges Village	31.2	1963	1990	28
01125000	French River at Webster	84	1950	1981	32
01333000	Green River at Williamstown	42.6	1950	1999	50
01170100	Green River nr. Colrain	41.4	1968	1999	32
01332500	Hoosic River nr Williamstown	126.0	1940	1997	58
01331500	Hoosic River nr. Adams	46.7	1932	1999	68
01174000	Hop Brook nr. New Salem	3.39	1948	1982	35
01199000	Housatonic River at Falls Village CT	634.0	1913	1999	87
01197500	Housatonic River nr. Great Barrington	282.0	1913	1997	85
01187300	Hubbard River near West Hartland CT	19.9	1939	1999	61
01105730	Indian Head River at Hanover	30.3	1967	1999	33
01101500	Ipswich River at S. Middleton	44.5	1938	1997	60
01102000	Ipswich River at Ipswich	125.0	1930	1997	68
01105870	Jones River at Kingston*	19.8	1967	1999	33
01124500	Little River nr. Oxford	26	1940	1990	51
01100000	Merrimack River below Concord R. at Lowell*	4635.0	1923	1997	75
01171500	Mill River at Northampton	54	1939	1999	61
01166500	Millers River at Erving	372	1916	1999	84
01164000	Millers River at South Royalston	189	1940	1990	51
01162000	Millers River nr. Winchendon	81.8	1917	1999	83
01097300	Nashoba Brook nr. Acton	12.8	1963	1997	35
01096500	Nashua River at E. Pepperell	435.0	1936	1997	62
01105000	Neponset River at Norwood	34.7	1940	1997	58
01094500	North Nashua River nr. Leominster	110	1936	1999	64
01169000	North River at Shattuckville	89.0	1940	1997	58
01105600	Old Swamp River nr. S. Weymouth	4.5	1966	1997	32
01163200	Otter River at Otter River	34.1	1965	1999	35

01101000	Parker River at Byfield	21.3	1946	1997	52
01162500	Priest Brook nr. Winchendon	19.4	1916	1997	82
01176000	Quaboag River nr. West Brimfield	150.0	1913	1999	87
01124000	Quinebaug River at Quinebaug CT	155	1932	1999	68
01123600	Quinebaug River nr Southbridge	99	1963	1990	28
01110000	Quinsigmond River at N. Grafton	25.6	1940	1999	60
01109070	Segreganset River nr. Dighton	10.6	1987	1999	13
01175670	Seven Mile River nr. Spencer, MA	8.68	1961	1999	39
01100600	Shawsheen River nr. Wilmington	36.5	1964	1997	34
01169900	South River nr. Conway	24.1	1967	1999	33
01096000	Squannacook River nr. West Groton*	65.9	1950	1997	48
01175500	Swift River at West Ware*	189	1913	1999	87
01161500	Tarbell Brook nr. Winchendon	17.8	1917	1983	67
01108000	Taunton River nr. Bridgewater	258.0	1930	1997	68
01109060	Threemile River at North Dighton	84.3	1967	1999	33
01187400	Valley Brook near West Hartland CT	7.03	1941	1972	32
01185500	W. Br. Farmington River nr New Boston	91.7	1913	1997	85
01181000	W. Br. Westfield River at Huntington	94.0	1935	1997	63
01108500	Wading River at Mansfield	19.5	1954	1986	33
01109000	Wading River nr. Norton	43.3	1925	1997	73
01173500	Ware River at Gibbs Crossing	197.0	1912	1997	86
01173000	Ware River at Intake Works nr. Barre	96.3	1929	1999	71
01172500	Ware River nr. Barre	55.1	1946	1997	52
01111200	West River nr. Uxbridge	27.9	1963	1990	28
01179500	Westfield River at Knightville	161	1910	1999	90
01183500	Westfield River nr. Westfield	497	1915	1999	85

*Gages with drainage areas that **include** watersheds from which water is being diverted

**Period of record includes the first and last full year of data. The actual period of record may be within 2 +/- years do to partial record years

Table 2. - Median of annual 7-day low flows for each gage

Station Name	Median of Annual 7-Day Low Flow in cfsm
Segreganset River nr. Dighton	0.01
Parker River at Byfield	0.02
Ipswich at S. Middleton	0.02
Ipswich River at Ipswich	0.04
Hop Brook nr. New Salem	0.04
Aberjona at Winchester	0.05
Seven Mile River nr. Spencer, MA	0.05
Nashoba Brook nr. Acton	0.05
Wading River at Mansfield	0.06
Hubbard River near West Hartland CT	0.06
Ware River nr. Barre	0.07
East Branch Tully River nr. Athol	0.07
Cadwell Creek nr. Belchertown	0.07
Valley Brook near West Hartland CT	0.07
East Br. Swift nr. Hardwick	0.07
Quinsigmond River at N. Grafton	0.08
Priest Brook nr. Winchendon	0.08
Little River nr. Oxford	0.09
Old Swamp River nr. S. Weymouth	0.09
Wading River nr. Norton	0.10
Charles River at Waltham	0.10
West River nr. Uxbridge	0.11
W. Br. Westfield at Huntington	0.11
Tarbell Brook nr. Winchendon	0.12
Shawsheen River nr. Wilmington	0.13
Charles River at Wellesley	0.13
Westfield River at Knightville*	0.13
French River at Hodges Village	0.14
Ware River at Intake Works nr. Barre	0.14
Indian Head River at Hanover	0.15
Assabet at Maynard	0.15
Threemile River at North Dighton	0.16
North River at Shattuckville	0.16
Quinebaug River at Quinebaug CT	0.16
Millers River nr. Winchendon	0.16
W. Br. Farmington nr New Boston	0.16
Charles River at Dover	0.17
Squannacook nr. West Groton	0.17
Quinebaug River nr Sturbridge	0.17
Ware River at Gibbs Crossing	0.17
Concord below R. Meadow at Lowell	0.18
Mill River at Northampton	0.18
Green River at Williamstown	0.18
Green River nr. Colrain	0.18
Taunton River nr. Bridgewater	0.19

Neponset River at Norwood	0.19
Millers River at Erving	0.19
Nashua at E. Pepperell	0.20
Quaboag nr. West Brimfield	0.20
Swift River at West Ware	0.20
Millers River at South Royalston	0.20
Fort River nr. Amherst	0.21
South River nr. Conway	0.21
East Br. Neponset River at Canton	0.22
Otter River at Otter River	0.22
Westfield River nr. Westfield	0.23
French River at Webster	0.24
Chicopee River at Indian Orchard	0.26
Merrimack below Concord R. at Lowell	0.27
Housatonic at Falls Village CT	0.28
Connecticut River at Montague	0.31
Blackstone at Woonsocket	0.31
Connecticut River at Thompsanville CT	0.32
E. Br. Housatonic River at Coltsville	0.33
Jones River at Kingston*	0.36
Housatonic nr. Great Barrington	0.36
Deerfield River nr. West Deerfield	0.37
North Nashua nr. Leominster	0.39
Hoosic River nr. Adams	0.39
Hoosic River nr Williamstown	0.43
Deerfield River at Charlemont	0.45

Table 3. - Median of annual 30-day low flows for each gage

Station Name	Median of Annual 30-day Low Flow in cfsm
Ipswich at S. Middleton	0.04
Segreganset River nr. Dighton	0.04
Parker River at Byfield	0.05
Ipswich River at Ipswich	0.08
Aberjona at Winchester	0.09
Seven Mile River nr. Spencer, MA	0.10
Valley Brook near West Hartland CT	0.10
Nashoba Brook nr. Acton	0.10
Hop Brook nr. New Salem	0.11
East Branch Tully River nr. Athol	0.12
Hubbard River near West Hartland CT	0.12
Priest Brook nr. Winchendon	0.13
Ware River nr. Barre	0.13
East Br. Swift nr. Hardwick	0.13
Wading River at Mansfield	0.14
Wading River nr. Norton	0.16
West River nr. Uxbridge	0.16
Little River nr. Oxford	0.16
Charles River at Waltham	0.16
Cadwell Creek nr. Belchertown	0.16
Tarbell Brook nr. Winchendon	0.18
Ware River at Intake Works nr. Barre	0.19
W. Br. Westfield at Huntington	0.19
Quinsigmond River at N. Grafton	0.20
Old Swamp River nr. S. Weymouth	0.21
Westfield River at Knightville*	0.21
Charles River at Wellesley	0.21
French River at Hodges Village	0.22
Charles River at Dover	0.22
Swift River at West Ware	0.22
Indian Head River at Hanover	0.22
Assabet at Maynard	0.22
Squannacook nr. West Groton	0.23
Shawsheen River nr. Wilmington	0.24
Concord below R. Meadow at Lowell	0.24
Quinebaug River at Quinebaug CT	0.24
Ware River at Gibbs Crossing	0.24
Green River at Williamstown	0.24
Millers River nr. Winchendon	0.24
Quinebaug River nr Sturbridge	0.25
North River at Shattuckville	0.25
Green River nr. Colrain	0.25
Quaboag nr. West Brimfield	0.25
Threemile River at North Dighton	0.26

Taunton River nr. Bridgewater	0.26
Mill River at Northampton	0.26
Millers River at South Royalston	0.27
Millers River at Erving	0.27
Neponset River at Norwood	0.28
Nashua at E. Pepperell	0.29
South River nr. Conway	0.29
French River at Webster	0.30
Fort River nr. Amherst	0.30
W. Br. Farmington nr New Boston	0.30
East Br. Neponset River at Canton	0.32
Chicopee River at Indian Orchard	0.32
Otter River at Otter River	0.33
Westfield River nr. Westfield	0.33
Merrimack below Concord R. at Lowell	0.36
Housatonic at Falls Village CT	0.36
Blackstone at Woonsocket	0.40
Connecticut River at Montague	0.41
Connecticut River at Thompsanville CT	0.42
E. Br. Housatonic River at Coltsville	0.44
Housatonic nr. Great Barrington	0.47
Hoosic River nr. Adams	0.48
North Nashua nr. Leominster	0.48
Jones River at Kingston*	0.49
Hoosic River nr Williamstown	0.53
Deerfield River nr. West Deerfield	0.57
Deerfield River at Charlemont	0.68

Table 4. - Median of the annual low pulse duration for each gage

Station Name	Median of Annual Low Pulse Duration in Days
Swift River at West Ware	1.2
Deerfield River at Charlemont	3.1
Nashua at E. Pepperell	3.55
Connecticut River at Montague	3.61
Deerfield River nr. West Deerfield	3.8
Chicopee River at Indian Orchard	4.6
Housatonic nr. Great Barrington	5.19
Housatonic at Falls Village CT	5.4
Ware River at Gibbs Crossing	5.42
French River at Webster	5.5
Connecticut River at Thompsanville CT	5.7
E. Br. Housatonic River at Coltsville	6
Fort River nr. Amherst	6
Millers River nr. Winchendon	6.1
Merrimack below Concord R. at Lowell	6.24
Tarbell Brook nr. Winchendon	6.4
North Nashua nr. Leominster	6.6
Blackstone at Woonsocket	6.8
Hoosic River nr. Adams	6.8
Westfield River nr. Westfield	6.8
W. Br. Farmington nr New Boston	6.89
Jones River at Kingston*	7
Neponset River at Norwood	7.09
Hoosic River nr Williamstown	7.17
Aberjona at Winchester	7.19
Mill River at Northampton	7.3
South River nr. Conway	7.4
Shawsheen River nr. Wilmington	7.56
Cadwell Creek nr. Belchertown	7.6
Millers River at Erving	8
North River at Shattuckville	8
Old Swamp River nr. S. Weymouth	8
W. Br. Westfield at Huntington	8.05
Westfield River at Knightville*	8.3
Assabet at Maynard	8.31
Charles River at Waltham	8.33
Hop Brook nr. New Salem	8.4
Quinebaug River at Quinebaug CT	8.6
Little River nr. Oxford	8.7
Nashoba Brook nr. Acton	8.72
East Br. Neponset River at Canton	8.9
Priest Brook nr. Winchendon	9.17
Green River nr. Colrain	9.5
Hubbard River near West Hartland CT	9.5
Green River at Williamstown	9.7

Millers River at South Royalston	10
Wading River nr. Norton	10.14
Valley Brook near West Hartland CT	10.2
Taunton River nr. Bridgewater	10.29
Ware River at Intake Works nr. Barre	10.3
Otter River at Otter River	10.6
West River nr. Uxbridge	10.7
Ware River nr. Barre	10.71
Indian Head River at Hanover	10.9
Charles River at Wellesley	11
Quinsigmond River at N. Grafton	11
Wading River at Mansfield	11
French River at Hodges Village	11.2
Seven Mile River nr. Spencer, MA	11.3
East Branch Tully River nr. Athol	11.4
Ipswich at S. Middleton	11.5
Squannacook nr. West Groton	11.5
Quinebaug River nr Sturbridge	11.7
Quaboag nr. West Brimfield	12
East Br. Swift nr. Hardwick	12.63
Concord below R. Meadow at Lowell	13.67
Segreganset River nr. Dighton	13.8
Threemile River at North Dighton	13.9
Charles River at Dover	14
Ipswich River at Ipswich	14.8
Parker River at Byfield	21

All river basins did not have adequate coverage of stream gages to be included in this analysis. The map of stress classifications shows these areas as white. No conclusions can be made about the degree of stress in these basins. In particular, the Cape and the Islands have not been included in this analysis. Gages outside of Massachusetts were used in a couple of cases where there was a lack of sufficient coverage in the basin and a gage was available on the same river near the Massachusetts border. In these cases only gages which measured flow originating predominantly within Massachusetts were used. Examples include the Quinebaug River gage in Quinebaug, Connecticut, the Housatonic River gage in Falls Village, Connecticut and the Blackstone Rive gage in Woonsocket, Rhode Island.

In some cases multiple gages are available for the same river. An example is the Charles River Basin which has gages at Dover, Wellesley, and Waltham. It was determined that due to the potential for cumulative impacts, when a downstream gage was classified as highly stressed, the remainder of the basin upstream would be considered stressed as well.

As mentioned under limitations this method provides a relative comparison of stream gages. The values for the breaks between high, medium and low are only useful for grouping basins and have not been correlated to any habitat requirements.

Figure 2. - Median of Annual 7-day Low Flow

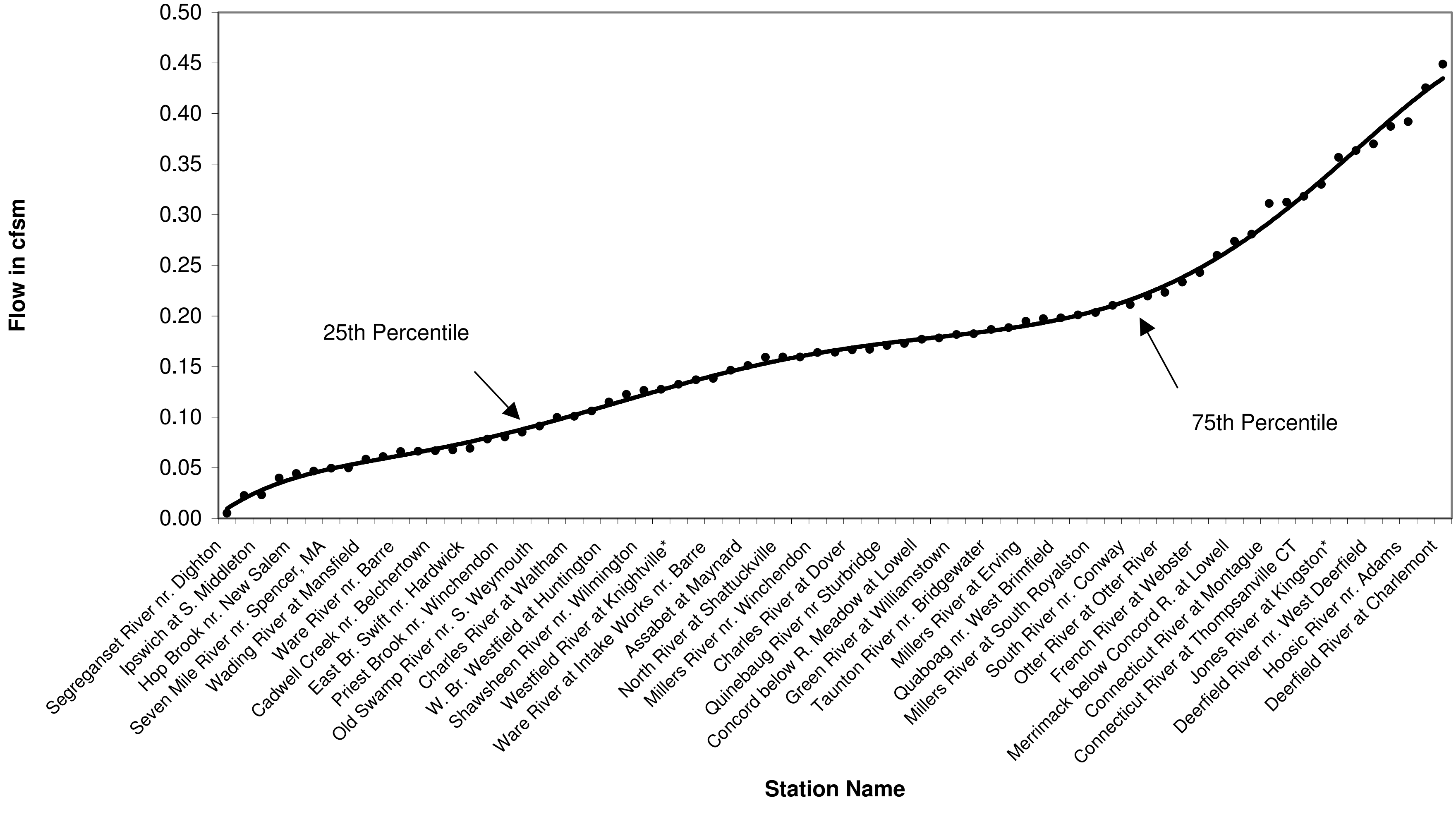


Figure 3. - Median of Annual 30-day Low Flow

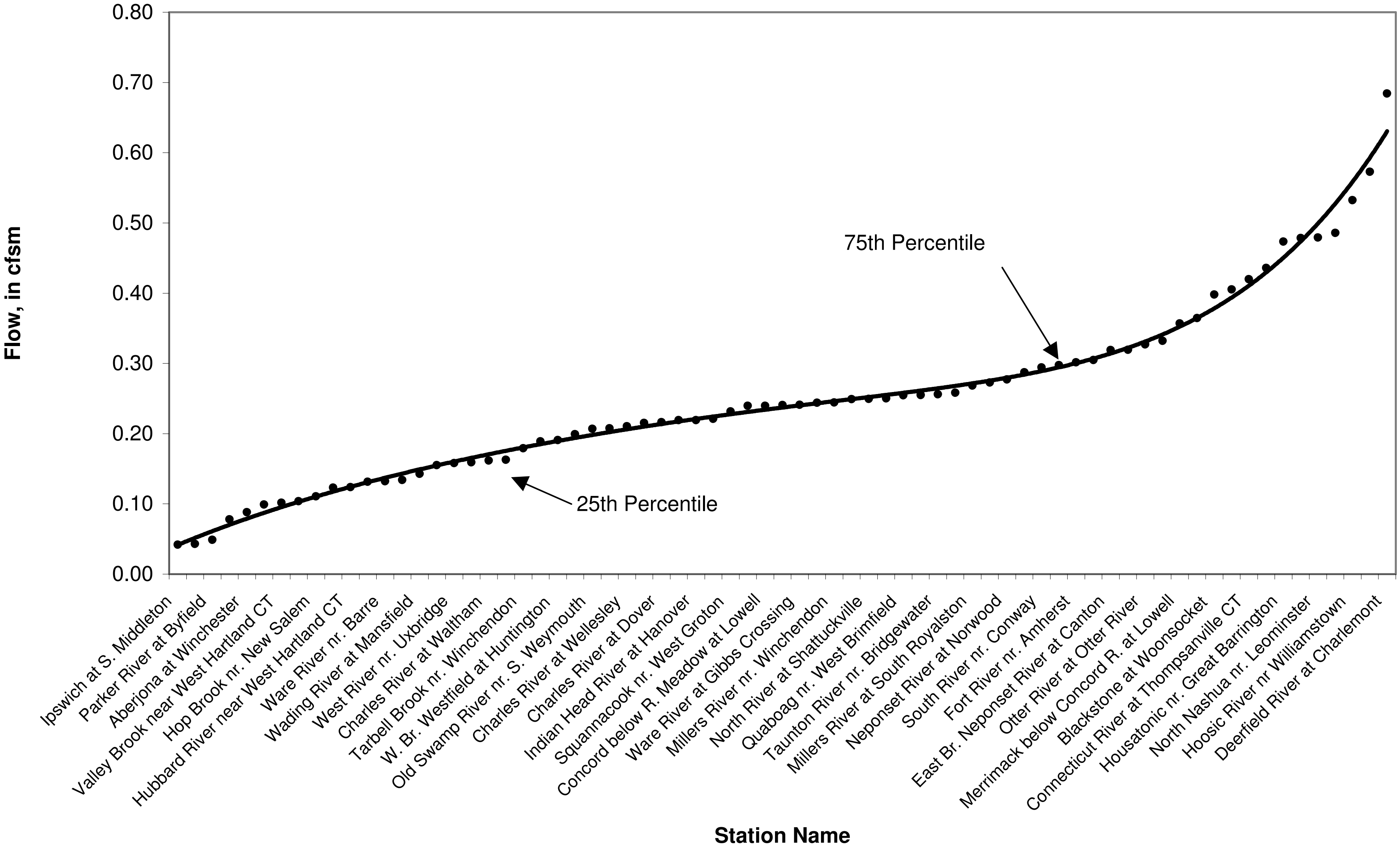


Figure 4. - Median of Annual Low Pulse Duration

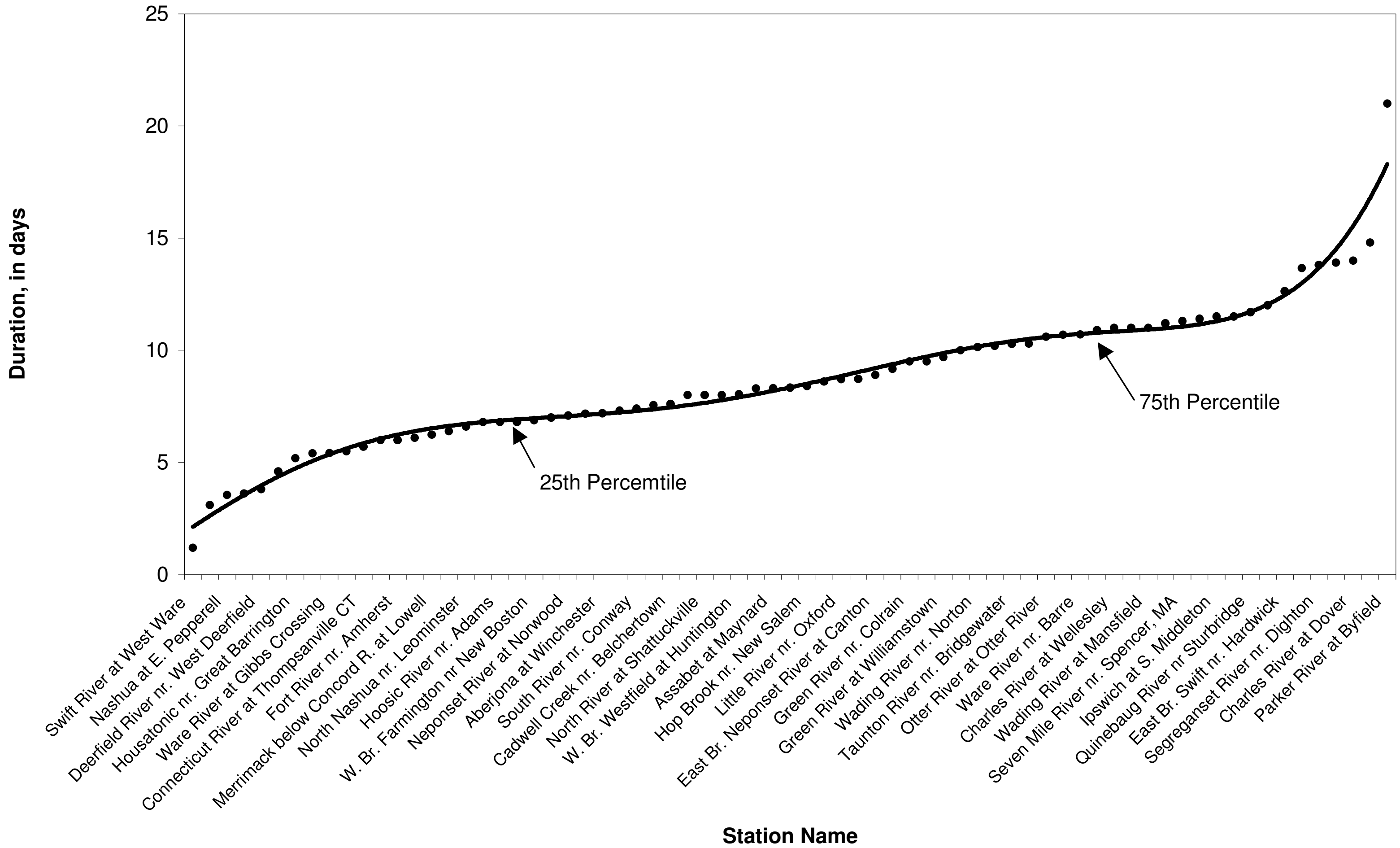


Table 5. – Matrix of high, medium and low classifications for each gage

Station #	Station Name	DRAFT 7-DAY Classification	DRAFT 30-DAY Classification	DRAFT Low Pulse Classification
01102500	Aberjona at Winchester	HIGH	HIGH	MEDIUM
01097000	Assabet at Maynard	MEDIUM	MEDIUM	MEDIUM
01112500	Blackstone at Woonsocket	LOW	LOW	LOW
01174900	Cadwell Creek nr. Belchertown	HIGH	MEDIUM	MEDIUM
01103500	Charles River at Dover	MEDIUM	MEDIUM	HIGH
01104500	Charles River at Waltham	MEDIUM	MEDIUM	MEDIUM
01104200	Charles River at Wellesley	MEDIUM	MEDIUM	HIGH
01177000	Chicopee River at Indian Orchard	LOW	LOW	LOW
01099500	Concord below R. Meadow at Lowell	MEDIUM	MEDIUM	HIGH
01170500	Connecticut River at Montague	LOW	LOW	LOW
01184000	Connecticut River at Thompsanville CT	LOW	LOW	LOW
01168500	Deerfield River at Charlemont	LOW	LOW	LOW
01170000	Deerfield River nr. West Deerfield	LOW	LOW	LOW
01197000	E. Br. Housatonic River at Coltsville	LOW	LOW	LOW
01105500	East Br. Neponset River at Canton	LOW	LOW	MEDIUM
01174500	East Br. Swift nr. Hardwick	HIGH	HIGH	HIGH
01165000	East Branch Tully River nr. Athol	HIGH	HIGH	HIGH
01171300	Fort River nr. Amherst	MEDIUM	LOW	LOW
01124350	French River at Hodges Village	MEDIUM	MEDIUM	HIGH
01125000	French River at Webster	LOW	LOW	LOW
01333000	Green River at Williamstown	MEDIUM	MEDIUM	MEDIUM
01170100	Green River nr. Colrain	MEDIUM	MEDIUM	MEDIUM
01332500	Hoosic River nr Williamstown	LOW	LOW	MEDIUM
01331500	Hoosic River nr. Adams	LOW	LOW	LOW
01174000	Hop Brook nr. New Salem	HIGH	HIGH	MEDIUM
01197500	Housatonic at Falls Village CT	LOW	LOW	LOW
01199000	Housatonic nr. Great Barrington	LOW	LOW	LOW
01187300	Hubbard River near West Hartland CT	HIGH	HIGH	MEDIUM
01105730	Indian Head River at Hanover	MEDIUM	MEDIUM	HIGH
01101500	Ipswich at S. Middleton	HIGH	HIGH	HIGH
01102000	Ipswich River at Ipswich	HIGH	HIGH	HIGH
01124500	Little River nr. Oxford	MEDIUM	MEDIUM	MEDIUM
01100000	Merrimack below Concord R. at Lowell	LOW	LOW	LOW
01171500	Mill River at Northampton	MEDIUM	MEDIUM	MEDIUM
01166500	Millers River at Erving	MEDIUM	MEDIUM	MEDIUM
01164000	Millers River at South Royalston	MEDIUM	MEDIUM	MEDIUM
01162000	Millers River nr. Winchendon	MEDIUM	MEDIUM	LOW
01097300	Nashoba Brook nr. Acton	HIGH	HIGH	MEDIUM
01096500	Nashua at E. Pepperell	MEDIUM	MEDIUM	LOW
01105000	Neponset River at Norwood	MEDIUM	MEDIUM	MEDIUM
01094500	North Nashua nr. Leominster	LOW	LOW	LOW
01169000	North River at Shattuckville	MEDIUM	MEDIUM	MEDIUM
01105600	Old Swamp River nr. S. Weymouth	MEDIUM	MEDIUM	MEDIUM
01163200	Otter River at Otter River	LOW	LOW	MEDIUM

01101000	Parker River at Byfield	HIGH	HIGH	HIGH
01162500	Priest Brook nr. Winchendon	HIGH	HIGH	MEDIUM
01176000	Quaboag nr. West Brimfield	MEDIUM	MEDIUM	HIGH
01124000	Quinebaug River at Quinebaug CT	MEDIUM	MEDIUM	MEDIUM
01123600	Quinebaug River nr Sturbridge	MEDIUM	MEDIUM	HIGH
01110000	Quinsigmond River at N. Grafton	HIGH	MEDIUM	HIGH
01109070	Segreganset River nr. Dighton	HIGH	HIGH	HIGH
01175670	Seven Mile River nr. Spencer, MA	HIGH	HIGH	HIGH
01100600	Shawsheen River nr. Wilmington	MEDIUM	MEDIUM	MEDIUM
01169900	South River nr. Conway	MEDIUM	MEDIUM	MEDIUM
01096000	Squannacook nr. West Groton	MEDIUM	MEDIUM	HIGH
01175500	Swift River at West Ware	MEDIUM	MEDIUM	LOW
01161500	Tarbell Brook nr. Winchendon	MEDIUM	MEDIUM	LOW
01108000	Taunton River nr. Bridgewater	MEDIUM	MEDIUM	MEDIUM
01109060	Threemile River at North Dighton	MEDIUM	MEDIUM	HIGH
01187400	Valley Brook near West Hartland CT	HIGH	HIGH	MEDIUM
01185500	W. Br. Farmington nr New Boston	MEDIUM	LOW	MEDIUM
01181000	W. Br. Westfield at Huntington	MEDIUM	MEDIUM	MEDIUM
01108500	Wading River at Mansfield	HIGH	HIGH	HIGH
01109000	Wading River nr. Norton	MEDIUM	MEDIUM	MEDIUM
01173500	Ware River at Gibbs Crossing	MEDIUM	MEDIUM	LOW
01173000	Ware River at Intake Works nr. Barre	MEDIUM	MEDIUM	MEDIUM
01172500	Ware River nr. Barre	HIGH	HIGH	MEDIUM
01111200	West River nr. Uxbridge	MEDIUM	MEDIUM	MEDIUM
01179500	Westfield River at Knightville	MEDIUM	MEDIUM	MEDIUM
01183500	Westfield River nr. Westfield	LOW	LOW	LOW

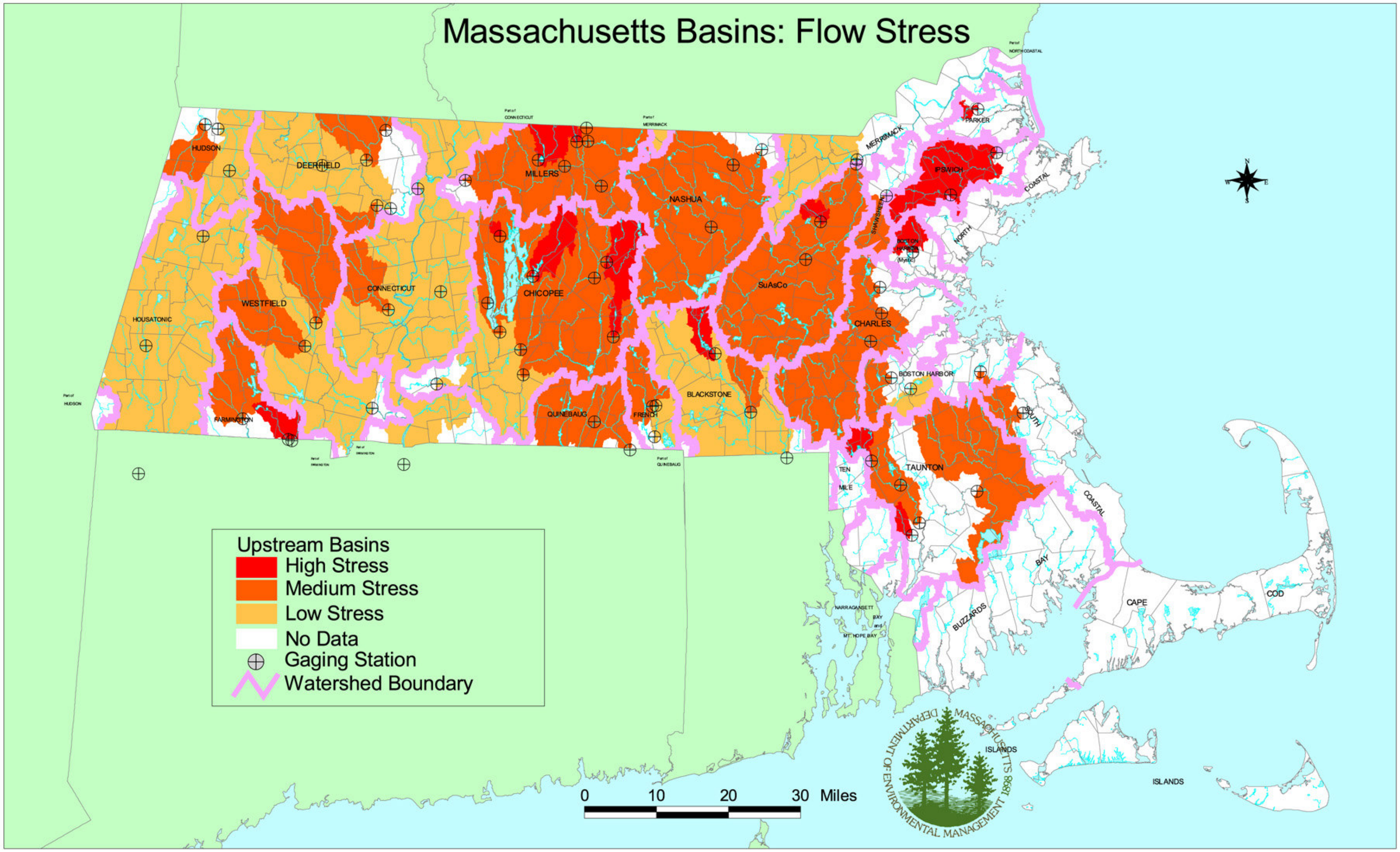
Table 6. – Final stress classifications

Station #	Station Name	FINAL STRESS LEVEL
01102500	Aberjona at Winchester	HIGH
01174500	East Br. Swift nr. Hardwick	HIGH
01165000	East Branch Tully River nr. Athol	HIGH
01174000	Hop Brook nr. New Salem	HIGH
01187300	Hubbard River near West Hartland CT	HIGH
01101500	Ipswich at S. Middleton	HIGH
01102000	Ipswich River at Ipswich	HIGH
01097300	Nashoba Brook nr. Acton	HIGH
01101000	Parker River at Byfield	HIGH
01162500	Priest Brook nr. Winchendon	HIGH
01110000	Quinsigmond River at N. Grafton	HIGH
01109070	Segreganset River nr. Dighton	HIGH
01175670	Seven Mile River nr. Spencer, MA	HIGH
01187400	Valley Brook near West Hartland CT	HIGH
01108500	Wading River at Mansfield	HIGH
01172500	Ware River nr. Barre	HIGH
01097000	Assabet at Maynard	MEDIUM
01174900	Cadwell Creek nr. Belchertown	MEDIUM
01103500	Charles River at Dover	MEDIUM
01104500	Charles River at Waltham	MEDIUM
01104200	Charles River at Wellesley	MEDIUM
01099500	Concord below R. Meadow at Lowell	MEDIUM
01124350	French River at Hodges Village	MEDIUM
01333000	Green River at Williamstown	MEDIUM
01170100	Green River nr. Colrain	MEDIUM
01105730	Indian Head River at Hanover	MEDIUM
01124500	Little River nr. Oxford	MEDIUM
01171500	Mill River at Northampton	MEDIUM
01166500	Millers River at Erving	MEDIUM
01164000	Millers River at South Royalston	MEDIUM
01162000	Millers River nr. Winchendon	MEDIUM
01096500	Nashua at E. Pepperell	MEDIUM
01105000	Neponset River at Norwood	MEDIUM
01169000	North River at Shattuckville	MEDIUM
01105600	Old Swamp River nr. S. Weymouth	MEDIUM
01176000	Quaboag nr. West Brimfield	MEDIUM
01124000	Quinebaug River at Quinebaug CT	MEDIUM
01123600	Quinebaug River nr Southbridge	MEDIUM
01100600	Shawsheen River nr. Wilmington	MEDIUM
01169900	South River nr. Conway	MEDIUM
01096000	Squannacook nr. West Groton	MEDIUM
01175500	Swift River at West Ware	MEDIUM
01161500	Tarbell Brook nr. Winchendon	MEDIUM
01108000	Taunton River nr. Bridgewater	MEDIUM
01109060	Threemile River at North Dighton	MEDIUM

01185500	W. Br. Farmington nr New Boston	MEDIUM
01181000	W. Br. Westfield at Huntington	MEDIUM
01109000	Wading River nr. Norton	MEDIUM
01173500	Ware River at Gibbs Crossing	MEDIUM
01173000	Ware River at Intake Works nr. Barre	MEDIUM
01111200	West River nr. Uxbridge	MEDIUM
01179500	Westfield River at Knightville	MEDIUM
01112500	Blackstone at Woonsocket	LOW
01177000	Chicopee River at Indian Orchard	LOW
01170500	Connecticut River at Montague	LOW
01184000	Connecticut River at Thompsanville CT	LOW
01168500	Deerfield River at Charlemont	LOW
01170000	Deerfield River nr. West Deerfield	LOW
01197000	E. Br. Housatonic River at Coltsville	LOW
01105500	East Br. Neponset River at Canton	LOW
01171300	Fort River nr. Amherst	LOW
01125000	French River at Webster	LOW
01332500	Hoosic River nr Williamstown	LOW
01331500	Hoosic River nr. Adams	LOW
01197500	Housatonic at Falls Village CT	LOW
01199000	Housatonic nr. Great Barrington	LOW
01100000	Merrimack below Concord R. at Lowell	LOW
01183500	Westfield River nr. Westfield	LOW
01094500	North Nashua nr. Leominster	MEDIUM*
01163200	Otter River at Otter River	MEDIUM*

* Data for the Otter River and the North Nashua River watersheds indicate a low stress classification, however they are classified as Medium stress due to a medium stress classification down gradient.

Figure 5 – stressed basin map



<u>Method to Determine if a Sub-basin is Hydrologically Stressed</u>

The stressed sub-basin analysis is a simple water budget comprised of withdrawals and discharges to the sub-basin. The amount of withdrawals and discharges are related to base flow to determine the relative impact of water use on the hydrology of the sub-basin with a focus on low flow periods.

1. The first step in the method is to delineate the tertiary or secondary sub-basin to be assessed. If a mainstem river is to be assessed an appropriate planning unit should be determined such that key hydrologic characteristics and water uses are captured in the sub-basin delineation.
2. Once the sub-basin has been delineated, municipal water supply withdrawals should be located. If possible average annual withdrawals, on a daily basis, for a three year period should be used.
3. Wastewater returns to the sub-basin should also be located and summarized. Careful attention should be paid to determining which portions of a community discharge to the sub-basin via a treatment plant versus areas that discharge via septic systems.
4. The total sub-basin withdrawals, wastewater treatment plant returns and septic returns should be summarized as well as the resulting net inflow or outflow of water from the sub-basin.
5. Determine the estimated natural 7Q10 and August Median flows for the sub-basin. This data is available from the U.S. Geological Survey at http://ma.water.usgs.gov/streamstats/. This web site does not currently provide these data for the Taunton, North Coastal and Buzzards Bay Basins.

STRESS CLASSIFICATION	CRITERIA
HIGH	Net outflow equals or exceeds estimated natural August median flow
MEDIUM	Net outflow equals or exceeds estimated natural 7Q10 flow
LOW	No net loss to the sub-basin

Past inflow/outflow analyses carried out by DEM used a similar method for calculating potential sub-basin yield and stress in a sub-basin. These analyses used the 95% flow duration for the 1980-81 drought. However the 1980-81 drought varied significantly across the state, therefore more reliable statistics have been chosen.

Use of the Stress Classification

EOEA agencies were asked to determine how the stressed basin classification could be used in state environmental programs. In general it was determined that all programs would use the stress delineation where available to flag areas which should undergo a higher level of review. In addition a requirement for project mitigation proportional to the degree of stress can be required by an agency. Finally, agencies that provide funding opportunities could include criteria that would support funding requests that address issues related to the stress classification, such as using the method provided in this definition to identify the level of stress of subbasins, or to mitigate habitat, water quality or water quantity impacts related to stress.

Specifically, the following programs are recommending to use the stressed classification:

1. Interbasin Transfer Act - a stressed classification for a sub-basin would be part of the criteria for evaluating determinations of insignificance. A proposed transfer from a stressed sub-basin could be determined to be significant. For a full application for an interbasin transfer, a stressed classification could also result in a requirement for stream monitoring and resource surveys as part of the information provided in the application. Stressed classifications would also be a factor in reviewing alternatives.

2. New Source Approval - The stressed classification would be included in the site screening document to guide communities on where to look for water supply and to provide a flag for areas which would undergo a higher level of review in the Water Management Act Program.

3. Water management Act - The DEP could identify those basins designated as stressed and require higher performance standards for communities requesting new withdrawal permits. The requirements could mirror the stricter conservation performance standards required in Interbasin Transfer Act applications.

4. NPDES Stormwater Phase 2 – The DEP is investigating avenues to emphasize, in stressed basins, stormwater recharge to the ground rather than simply cleaning up discharges to surface waters. It is most likely that this emphasis will need to be addressed within the required stormwater management plans.

5. Comprehensive Wastewater Management Planning (CWMP) guidance – The draft guidance already requires greater emphasis on local recharge of wastewater and increased emphasis on infiltration/inflow control in stressed basins. The regulatory implementation of the recommendations contained in CWMPs will occur as a result of future permitting and funding decisions.

Recommendations

1. <u>Obtain Data</u>

The committee concluded that it is not currently possible to identify sub-basins of the Commonwealth that should be labeled as stressed on a statewide basis. This conclusion is based primarily on the lack of computerized data. Although a definition was developed using quantity, quality and habitat factors, the data necessary for this analysis is in hard copy form only. This data includes water use data, the 303d list, fisheries presence/absence data, target fish community data and location of dams.

The committee recommends that the hard copy data be computerized and has taken the following steps:

- The U.S. Geological Survey is computerizing the water withdrawal data submitted to the Department of Environmental Protection (DEP) as part of the DEM and DEP cooperative studies program.
- 2000 water use data is being incorporated into MASS GIS.
- Communities are being encouraged to computerize water system and wastewater system distribution information as part of EO 418.
- The Division of Fisheries and Wildlife is continuing an ongoing effort to computerize fisheries information.

2. Use Interim Methods to Determine Quantitative Stress

A lack of computerized data make it impossible to delineate stressed sub-basins statewide in a timely manner. Therefore the committee developed two methods which incorporate portions of the definition for interim use until a statewide assessment on a sub-basin level is possible. Because streamflow is the basic requirement for quality and habitat factors, the committee developed two methods to use to determine quantitative stress. The first method is a statewide first cut to classify the levels of hydrological stress for large basins and sub-basins as high, medium and low. This classification is intended to be an interim delineation until the remaining required data is developed. The second method can be applied by project proponents to a sub-basin to determine existing and potential impacts to streamflow.

3. Future Work

Refine the interim basin delineation with additional water quality data, fish passage data and fisheries presence/absence data:

- The 303d list and other appropriate water quality data will be assessed to determine a method for adding reach data to the basin scale delineation. A quality determination of stress will be added to the matrix of hydrologic data and adjustments to the delineated basins will be made.
- DFW will be assessing Target Fish Communities for each river basin. This data should be used to refine the habitat portion of the stress definition.
- A similar analysis will be done using the fisheries presence/absence data and available data on limitations to fish passage.
- Look for new methods and data to refine the stress definition including developing a quality and quantity monitoring program for small streams.

APPENDIX 1

Summary of Agency Methods and Data
The following is a summary of the data and methods examined by the committee.

Data

1. Water Quality - the Massachusetts DEP maintains the 303d list, which is a list of surface water bodies which do not meet the surface water quality standards of the Clean Water Act. This list is updated every two years and submitted to EPA. Sub-basins drained by rivers or streams on the list can be classified as stressed (impaired). However streams not listed cannot be assumed to be "unstressed" (not impaired) as they may not have been sampled recently or the sample results may be inconclusive.

2. Aquatic Habitat – The Division of Fisheries and Wildlife surveys fisheries in Massachusetts streams and has data goings back to the late 1800's. Some data is computerized and some is in hard copy files. Historic data collected indicating presence of a species can be compared to more recent surveys. The absence of a species formerly surveyed may indicate a stressed basin. However this method is limited by the quality of the older data. In addition, the current survey data is time sensitive, and must be updated to draw any conclusions.

3. Streamflow Statistics – The U.S. Geological Survey has developed an internet program, which estimates natural streamflow at any location on a river or stream. These estimated statistics could be compared to nearby gage statistics to determine a change in flow or stress. This method is only useful at sites with stream gages and is limited by the error of the estimates. These errors become smaller, in relative terms, in larger drainage areas such as those found at gaging stations.

4. Streamflow Statistics – The Nature Conservancy has developed a list of streamflow statistics which it feels can reflect impacts to streams. This data is a useful tool for looking at stress in terms of impacted streams but is limited to stream gage sites with an adequate period of record and in which the stress is "known," such as construction of a dam. The method compares statistics of pre-impact flows to post-impact flows. In addition determining an area to be "unstressed" is difficult if impacts pre-dated the gage period of record.

Current Methods

1. DEP Site Screening Document (Attachment 1) – the DEP Site Screening Document (SSD) was designed as a guide to help those developing new water supplies to take a first cut at identifying potential environmental impacts related to the development of new water supply source development. The SSD has a number of criteria including identification of sensitive receptors and evaluation of potential impacts to streamflow. The committee focused on the work that had been done to identify potential impacts

to streamflow to see if they were useful as a method for defining stress. This method does not incorporate the cumulative impact of existing withdrawals.

2. <u>DEP Draft Sewer Impacts Analysis (Attachment 2)</u> – the DEP sewer analysis contains several methods for calculating the impact of a proposed sewer system to ground water recharge, streamflow and sensitive receptors. The methods involve comparing the amount of water to be sewered out of a sub-basin to the amount of annual recharge to the groundwater system and to the low flow in streams draining the sub-basin. The analysis also includes identification of sensitive receptors and analysis of impact to ground water levels. The streamflow analysis uses the DEM inflow/outflow methodology (see below). This method would be the most appropriate of the sewer analyses for calculating stress.

3. <u>DEM Inflow/Outflow Methodology</u> – the DEM inflow/outflow methodology involves calculating a water use budget for a sub-basin. The net inflow or outflow of water is compared to low-flow statistics for the stream draining the sub-basin. This method would involve choosing a flow criterion such as 7Q10, August median flow, or 1980-1981 98% flow, and comparing that criterion to the net inflow/outflow of the sub-basin. This method is limited by the lack of computerized water use data.

4. <u>Identification and Evaluation of a Target Fish Community</u> – see Attachment 3.